Chapter Two

Literature review

2.1Introduction:

For the structural engineer the major difference between low and tall buildings is the influence of the wind and earthquake forces on the behavior of the structural elements. Generally, it can be stated that a tall building structure is one in which the horizontal loads are an important factor in the structural design. In terms of lateral deflections a tall concrete building is one in which the structure, sized for gravity loads only, will exceed the allowable sway due to additionally applied lateral loads. This allowable drift is set by the code of practice. If the combined horizontal and vertical loads cause excessive bending moments and shear forces the structural system must be augmented by additional bracing elements. These could take several forms. Cross-sections of existing beams and columns can be enlarged or efficient lateral-load-resisting bents such as concrete shear walls can be added to the structure.

The analysis of tall structures pertains to the determination of the influence of applied loads on forces and deformations in the individual structural elements such as beams, columns and walls. The design deals with the proportioning of these members For reinforced concrete structures this includes sizing the concrete as well as the steel in an element. Structural analyses are commonly based on established energy principles and the theories developed from these principles assume linear elastic behaviour of the structural elements. Non-linear behaviour of the structure makes the problem extremely complex. It is very difficult to formulate, with reasonable accuracy the problems involving inelastic responses of building materials. At present the forces in structural components and the lateral drift of tall structures can be determined by means of an elastic method of analysis regardless of the method of design. Non-linear methods of analysis for high-rise structures are not readily available. [2]

2.2 Structural elements and frames

The complete building structure can be broken down into the following elements:

Beams:horizontal members carrying lateral loads.

Slabs:horizontal plate elements carrying lateral loads.

Columns: vertical members carrying primarily axial load but generally subjected to axial load and moment.

Bases and foundations:pads or strips supported directly on the ground that spread the loads from columns or walls so that they can be supported by the ground with out excessive settlement. Alternatively the bases may be supported on piles.

2.3 Structural design

The first function in design is the planning carried out by the architect to determine. the arrangement and layout of the building to meet the client's requirements. The structural engineer then determines the best structural system or forms to bring the architect's concept into being. Construction in different materials and with different arrangements and systems may require investigation to determine the most economical answer. Architect and engineer should work together at this conceptual design stage.

Once the building form and structural arrangement have been finalized the design problem consists of the following:

1. Idealization of the structure into load bearing frames and elements for analysis and design.
2. Estimation of loads.
3. Analysis to determine the maximum moments, thrusts and shears for design.
4. Design of sections and reinforcement arrangements for slabs, beams, columns and walls using the results from3.
5. Production of arrangement and detail drawings and bar schedules. [2].

2.4 Design standards

The design engineer is usually guided by specifications called the codes of practice. Engineering specifications are set up by various organizations to represent the minimum requirements necessary for the safety of the public, although they are not necessarily for the purpose of restricting engineers. Most codes specify design loads, allowable stress, material quality, construction types, and other requirements for building construction. The most significant code for structural concrete design in the united state is the building code requirements for structural concrete, ACI 318, or the ACI code. Other codes of practice and material specifications include the international Code, the British Standard (BS) Code of Practice for Reinforced Concrete,BS8110, the National Building Code of Canada, the German Code of Practice for reinforced concrete DIN1045, Technical Specifications for the Theory and Design of Reinforced Concrete Structures, CC-BA(France), And the Eurocode 2-199 2,etc . [3]

In this research three codes was used:

1- British code BS8110-1997 , 2- American code ACI 2005, European code EC-1992.

In the UK, design is generally to limit state theory in accordance with BS8110:1997. Structural Use of Concrete Part 1: Code of Practice for Design and Construction .The design of sections for strength is according to plastic theory based on behaviour at ultimate loads.

Elastic analysis of sections is also covered because this is used in calculations for deflections and crack width in accordance with BS 8110:1985: Structural Use of Concrete Part 2: Code of Practice for Special Circumstances

The loading on structures conforms to BS 6399–1:1996 Loading for buildings. Code of Practice for Dead and Imposed Loads

BS 6399–2:1997 Loading for buildings. Code of Practice for Wind Loads

BS 6399–3:1988 Loading for buildings. Code of Practice for Imposed Roof Loads.

2.5 Structural design and limit states:

*** Aims and Methods of Design**

The code BS 8110, part 1 in clause 2.1.1 states that the aim of design is the achievement of an acceptable probability that the structure will perform satisfactorily during its life.

It must carry the loads safely, not deform excessively and have adequate durability and resistance to the effects of misuse and fire. The clause recognizes that no structure can be made one hundred percent safe and that it is only possible to reduce the probability of failure to an acceptably low level.

Clause 2.1.2 states that the method recommended in the code is limit state design where account is taken of theory, experiment and experience. It adds that calculations alone are not sufficient to produce a safe, serviceable and durable structure. Correct selection of materials, quality control and supervision of construction are equally important.

2.6 Criteria for a Safe Design: Limit States

The criterion for a safe design is that the structure should not become unfit for use, i.e. that it should not reach a limit state during its design life. This is achieved, in particular, by designing the structure to ensure that it does not reach.

1. The ultimate limit state (ULS): the whole structure or its elements should not collapse, overturn or buckle when subjected to the design loads.

2. Serviceability limit states (SLS): the structure should not become unfit for use due to excessive deflection, cracking or vibration.

The structure must also be durable, i.e. it must not deteriorate or be damaged excessively by the environment to which it is exposed or action of substances coming into contact with it. The code places particular emphasis on durability. For reinforced concrete structures the normal practice is to design for the ultimate limit state, check for serviceability and take all necessary precautions to ensure durability.

2.6.1 Ultimate Limit State

(a) Strength

The structure must be designed to carry the most severe combination of loads to which it is subjected. Each and every section of the elements must be capable of resisting the axial loads, shears and moments derived from the analysis.

The design is made for ultimate loads and design strengths of materials with partial safety factors applied to loads and material strengths. This permits uncertainties in the estimation of loads and in the performance of materials to be assessed separately. The section strength is determined using plastic analysis based on the short-term design stress strain curves for concrete and reinforcing steel.

(b) Stability

Clause 2.2.2.1 of the BS8110-1997 code states that the layout should be such as to give a stable and robust structure. It stresses that the engineer responsible for overall stability should ensure compatibility of design and details of parts and components.

Overall stability of a structure is provided by shear walls, lift shafts, staircases and rigid frame action or a combination of these means. The structure should be such as to transmit all loads, dead, imposed and wind, safely to the foundations.

(c) Robustness

Clause 2.2.2.2 of theBS8110-1997 code states that the planning and design should be such that damage to a small area or failure of a single element should not cause collapse of a major part of a structure. This means that the design should be resistant to progressive collapse. The clause specifies that this type of failure can be avoided by taking the following precautions.

1. The structure should be capable of resisting notional horizontal loads applied at roof level and at each floor level. The loads are 1.5% of the characteristic dead weight of the structure between mid-height of the storey below and either mid-height of the storey above or the roof surface. The wind load is not to be taken as less than the notional horizontal load.

2. All structures are to be provided with effective horizontal ties. These are

(a) peripheral ties

(b) internal ties

(c) horizontal ties to column and walls

3. For buildings of five or more storeys , key elements are to be identified, failure of which would cause more than a limited amount of damage. These key elements must be designed for a specially heavy ultimate load of 34 kN/m applied in any direction on the area supported by the member. Provisions regarding the application of this load are set out in BS 8110: Part 2, section 2.6.

- 4. For buildings of five or more storeys it must be possible to remove any vertical load bearing element other than a key element without causing more than a limited amount of damage. This requirement is generally achieved by the inclusion of vertical ties in addition to the other provisions noted above.

2.6.2 Serviceability Limit States

The serviceability limit states are discussed in BS 8110: Part 1, section 2.2.3. The code states that account is to be taken of temperature, creep, shrinkage, sway and settlement and possibly other effects.

The main serviceability limit states and code provisions are as follows.

(a) Deflection

The deformation of the structure should not adversely affect its efficiency or appearance. Deflections may be calculated, but may tend to be complicated and in normal cases span to- effective depth ratios can be used to check compliance with requirements.

(b) Cracking

Cracking should be kept within reasonable limits by correct detailing. Crack widths may be calculated, but may tend to be complicated and in normal cases cracking can be controlled by adhering to detailing rules with regard to bar spacing in zones where the concrete is in tension.

In analyzing a section for the serviceability limit states the behavior is assessed assuming a linear elastic relationship for steel and concrete stresses. Allowance is made for the stiffening effect of concrete in the tension zone and for creep and shrinkage.[2]

2.7 EC2 Code philosophy

The general philosophy of EC2 is quite different from that found in BS 8110. The Euro- code is less empirical and more logical in its approach. For example, variables such as partial factors for materials are shown within formulae, rather than being “built in” as part of an obscure number. If one wishes to go into greater detail, there are appendices to the code that give derivation formulae for items such as creep coefficients and shrinkage strains, which are most helpful when attempting to automate the design process. EC2 makes no attempt to be a design “guide”; it is a code giving general rules. There are no simplified tables of moment or shear factors for example, as one would be expected to look for these in separate design guides or standard text books.[3]

2.7.1 Scope of Eurocode2

(1) Eurocode2 applies to the designof buildings and civil engineering works in plain, reinforced and prestressed concrete. It is subdivided into various separate parts.

(2) This Eurocode is only concerned with the requirements for resistance, serviceability and durability of structures. Other requirements, e.g. concerning thermal or sound, insulation, are not considered.

(3) Execution) is covered to the extent that is necessary to indicate the quality of the construction materials and products which should be used and the standard of workmanship on site needed to comply with the assumptions of the design rules. Execution and workmanship are covered in Chapters 6 and 7of the code , and are to be considered as minimum requirements which may have to be further developed for particular types of buildings or civil engineering works) and methods of construction).

(4) Eurocode 2 does not cover the special requirements of seismic design. Provisions related to such requirements are given in Eurocode 8 "Design of Structures in Seismic Regions" which complements, and is consistent with, Eurocode 2.

(5) Numerical values of the actions on buildings and civil engineering works to be taken into account in the design are not given in Eurocode2. They are provided in the Eurocode1 "Bases of Design and Actionson Structures" applicable to the various types of construction.

2.7.2 Scope of Part 1 of Eurocode2:

Part 1 of Eurocode2 gives a general basis for the design of buildings and civil engineering works in reinforced and prestressed concrete made with normal weight aggregates .In addition, Part 1 gives detailed rules which are mainly applicable to ordinary buildings. The applicability of these rules may be limited, for practical reasons or due to simplifications; their use and any limits of applicability are explained in the text where necessary. [4]

2.8 Scope of ACI 318-05 code:

ACI 318M-05 was adopted as a standard of the American ConcreteInstitute October 27, 2004 to supersede ACI 318M-02 in accordance with the Institute’s standardization procedure. The code portion of this document covers the design and construction of structural concrete used in buildings and where applicable in non building structures.

Among the subjects covered are: drawings and specifications; inspection; materials; durability requirements; concrete quality, mixing, and placing; formwork; embedded pipes; construction joints; reinforcement details; analysis and design; strength and serviceability; flexural and axial loads; shear and torsion; development and splices of reinforcement; slab systems; walls; footings; pre- cast concrete; composite flexural members; pre- stressed concrete; shells and folded plate members; strength evaluation of existing structures; special provisions for seismic design; structural plain concrete; strut-and-tie modeling in Appendix A; alternative design provisions in Appendix B; alternative load and strength-reduction factors in Appendix C; and anchoring to concrete in Appendix D.

Uses of the code include adoption by reference in general building codes, and earlier editions have been widely used in this manner. The code is written in a format that allows such reference without change to its language. Therefore, background details or suggestions for carrying out the requirements or intent of the code portion cannot be included. The commentary is provided for this purpose. Some of the considerations of the committee in developing the code portion are discussed within the commentary, with emphasis given to the explanation of new or revised provisions. Much of the research data referenced in preparing the code is cited for the user desiring to study individual questions in greater detail.[5]